COUNTDOWN ACID RAIN

AFTER TWO YEARS:

Summary and Analysis of the Fifth Progress Reports by Ontario's Four Major Sources of Sulphur Dioxide

November 1988

Environment Ontario

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Minister

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SUMMARY AND ANALYSIS OF THE FIFTH REPORTS (JULY 31, 1988) DETAILING EMISSIONS REDUCTION TECHNOLOGY DEVELOPMENT BY ONTARIO'S FOUR MAJOR EMITTERS OF SULPHUR DIOXIDE

THE ABATEMENT PLAN

Ontario's Countdown Acid Rain program, announced in December 1985, will reduce province-wide emissions limits of sulphur dioxide (SO_2) to 885 kilotonnes (thousand metric tonnes) by 1994, from the 1980 base case level of 2,194 kilotonnes (kt). This is to be accomplished by means of non-appealable regulations for the four corporate sources, Inco Ltd. and Falconbridge Ltd. (nickel/copper smelters in Sudbury), Algoma Steel Corporation Ltd. (iron sintering plant in Wawa), and Ontario Hydro (all its fossil-fuelled electric generating plants across the province). The four major sources produce about 80% of Ontario's SO_2 emissions.

The regulations specify emission reductions to start in 1986 and to be fully implemented by 1994. The regulations require the companies to file progress reports on their technology developments semi-annually, leading up to the final report by the end of 1988 (end of January 1989 for Ontario Hydro). The final report will show precisely the chosen abatement methods and technologies together with detailed financial implications. A complete description of Ontario's acid gas control program may be found in the Countdown Acid Rain information kit which is available through the Communications Branch, Ontario Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario M4V 1P5 (416-323-4321).

Sulphur dioxide emissions of each of the four corporate polluters (shown in Table 1) in 1987 were below the legal limit permitted by the four industry-specific regulations, the second full year in which the Countdown Acid Rain regulations were in full effect.

TABLE 1: 1987 SO_2 Emissions for Ontario's Major Emitters

	1987 Legal Limit (kt)	1987 Actual Emissions (kt)	Percentage of Annual Limit (%)
Algoma (Wawa)	180	85	47
Falconbridge	154	72	48
Hydro	370	332	90
Inco	685	658	96
TOTALS	1,389	1,147	83

As of July 1988, each of the four major SO_2 sources has submitted five progress reports showing its plans to meet the required future reductions. Copies of all the reports and the four previous summary and analysis reports are available from the Ministry of the Environment.

THE COMPANIES' REPORTS

All companies report that they are confident that they will stay below the stringent new emissions limits. By 1994, SO_2 annual emissions limits will be 265 kt, 100 kt, 125 kt, and 175 kt for Inco, Falconbridge, Algoma, and Ontario Hydro, respectively. Technical progress continues to be made, with both Sudbury companies reporting nickel and copper smelting advances. Detailed financial information is not yet available for most of the needed technical changes, because much of the development is not complete and the companies' final decisions await the results of commercial-scale testing. The final reports, due in December 1988 (January 1989 for Ontario Hydro) when the technology development period ends, must contain the technical details showing how the emission reductions will be accomplished. The companies are also required to submit semi-annual reports subsequently on the progress being made in implementing the emission reduction plans to be outlined in the final report.

SUDBURY ORE

All of the sulphur captured or emitted from the Inco and Falconbridge smelters comes from the ore being processed to yield its nickel, copper and other precious metals. Ores in the Sudbury Basin contain typically 73% by weight of rock, 20% by weight of the iron sulphide pyrrhotite and 7% of nickel and copper sulphides.

In the milling process, 98% of the rock is ejected as tailings. This results in removal of 5% of the ore's sulphur and 5% of its nickel. After tailings rejection, 25% of the remaining sulphur is combined in the copper and nickel minerals, and the rest in the pyrrhotite.

About three-quarters of the pyrrhotite is magnetic and is separated for rejection utilizing magnetic separators and flotation tanks. The other quarter of the pyrrhotite is non-magnetic and can be rejected by flotation.

Test results have shown that for Sudbury ores, total tailings and pyrrhotite rejection resulting in a removal of two-thirds of the ore's sulphur can be achieved while rejecting only material with a nickel content of less that 2%. This 67% sulphur removal prior to smelting is the level which the mining companies regard as the maximum which is economical.

INCO

In Sudbury, Inco operates a nickel/copper smelter with associated mining and milling operations, and manufactures sulphuric acid and liquid SO_2 from the sulphur in the ores. At 658,000 tonnes of SO_2 a year for 1987, Inco is one of the largest emitters of SO_2 in the world.

SO_2 emissions at Inco are very large, not only because of the very large scale of the operations, but also because of the high sulphur content in the ore due to the presence of pyrrhotite. The sulphur input to the smelter, which directly influences the amount of SO_2 generated in the smelter, is determined by the amount of pyrrhotite that can be segregated and rejected during the milling operations. Inco currently mines 11 million tonnes of ore per year containing 1.1 million tonnes of sulphur. If none of the sulphur were rejected or fixed and if it were all oxidized to SO_2, acid rain-causing emissions would be 2.2 million tonnes.

Countdown Acid Rain requires Inco to:

- limit its annual SO_2 emissions to 685 kt effective 1986,
- examine the possibility of reaching a limit of 525 kt per year by 1990,
- reduce its emissions to 265 kt per year by 1994, and
- examine the possibility of reaching an annual limit of 175 kt at an unspecified date.

INCO'S JULY 31, 1988 PROGRESS REPORT

SUMMARY	ONTARIO GOVERNMENT RESPONSE
The company's R&D budget indicates significant spending in the first half of 1988 with an overall R&D expenditure of $131 million since 1980.	Inco's fifth progress report meets the requirements of O. Reg. 660/85. Inco's conceptual plans to meet the regulation's SO_2 emissions limit are still consistent with those of the earlier reports, particularly the fourth progress report except for some diversions.
Inco's board of directors has approved $69 million capital expenditure for milling rationalization and new technology which is expected to reduce SO_2 annual emissions by 100 kt by increased pyrrhotite removal.	The fifth progress report does not provide details in this area related to sulphur rejection on a source basis.
The following changes are required to achieve the annual SO_2 emissions limit of 265 kt in	

a cost-effective way. The company has given the following breakdown on SO_2 emissions and fixation from individual sources.

Source/Operation	Estimated SO_2 Emissions Fixed (kt/yr) Previous	Current	SO_2 Emitted (kt/yr)
Increased Pyrrhotite Rejection	(100)	(100)	-
Flash Furnaces	370	395	20
Bessemer Matte Converters	-	-	145
Matte Processing Roasters	30	-	75
MK Flash Converter	40	60	5
Copper Finishing Converter	-	-	15
Top Blown Rotary Converter (CCNR)	-	-	5
Subtotal	440	455	265

A. Increased Pyrrhotite (PO) Rejection:

Mineral processing techniques have been changed from SO_2/air-lime treatment of non-magnetic PO stream to overall mill rationalization based on cost-effectiveness. A similar amount (i.e., 50 kt of S equivalent or 100 kt of SO_2) reduction at the smelter is expected by using finer regrind of ore, chemically treated water, increased residence time in flotation cells, and higher intensity of magnetic separators. This new technology is expected to produce concentrates with 14% Ni at an 82% Ni recovery.

Inco's Mills Rationalization program for pyrrhotite rejection appears to be a viable technology, however, details on mill rationalization studies are not stated in the fifth progress report. Assessment of this choice for SO_2 reduction can only be evaluated once implementation has occurred.

If this program is not realized, higher sulphur emissions would result when operating the smelter at design rate. It is not completely clear which PO rejection processes will be used and how much additional sulphur will be removed. Inco should provide these details in the final report. Some of the PO rejection benefits in SO_2 reduction could be realized before 1993.

B. Bulk Concentrate Smelting in New Flash Furnace (2):

This report suggests that Inco is planning to produce higher grade matte meaning more sulphur will be removed as high strength SO_2 gas and less SO_2 (up to 30 kt) will be generated in bessemer matte converting.

This looks like a good approach. H_2S contamination of off-gases could create problems in meeting liquid SO_2 specifications. Why the H_2S is formed, what effect it will have on plant operations, and how the problem can be resolved should be discussed.

The report mentions that "a number of outstanding questions remain to be addressed and resolved before the commercial viability of all phases of the bulk smelting can be established...".

More information is needed from the company.

SO_2 Fixation:

The company has opted for a new double contact acid plant near the flash furnaces (Copper Cliff Smelter) for consistency and flexibility reasons instead of a SO_2 pipeline of 5 km, and the use of the old single contact acid plant.

This looks most appropriate and a responsible decision. Together with bulk smelting this alternative will fix an additional 25 kt of SO_2. However, since the company is planning to keep its existing acid storage facilities, the need for a sulphuric acid pipeline arises. The company will have to supply information on the design of this pipeline.

C. Bessemer Matte Converter:

No positive controls are being planned for this operation except an annual reduction of 30 kt of SO_2 emissions from this source resulting from higher matte grade feed.

Technical problems due to the formation of high melting point oxidic mush, proper converter heat balance and use of reducing agents/fuels still persist and need to be resolved. If not solved it could mean limited use of scrap in converting and could affect the nickel scrap recycle market. More details are needed on the use of N_2/air mixtures in tuyers to reduce NiO mush to ensure no increase of NO_x emissions from this source.

D. Nickel Sulphide Matte Processing Roasters:

SO_2 emissions which were shown earlier to be partly controlled (up to 30 kt/yr) have been dropped from current plans on the basis of economics.	The company appears to have rejected fluid bed roaster gas collection and treatment, at least in the foreseeable future. There is not enough information in the report to justify this rejection based on economics. The alternative approach, flash converting, if successful, will be the solution to the company for lowering emissions below the 175 kt target. It also addresses the largest sulphur dioxide source that was not in the plans for smelter emissions capture and treatment. A number of changes are needed in the matte separation processes e.g. metallic separation and Ni/Cu sulphide concentrates separation using flotation. Additional work is needed to limit Ni contamination in copper sulphides since all the copper circuit material in the future will be supplied by the matte separation circuit. Information on flash converting and possible timing should be provided.

E. MK Flash Converter:

The new program is expected to produce semi-blister copper thereby fixing an additional 20 kt of SO_2 from this source.	

F. Copper Finishing Converters

Inco indicated that "very encouraging results have been obtained from tests using a novel concept for washout practice".	More information from the company is required.

G. Top-Blown Rotary Converters

Used for nickel sulphide treatment in CCNRC are minor sources of SO_2 and will not be controlled.	After implementing the proposed SO_2 abatement program, the fluid-bed roasters and acid plant at CCNR will probably cease to operate.

Air Quality

The company has indicated that it will be unable to meet the SO_2 GLC requirements of Reg. 308 even if they are successful in meeting Reg. 660/85 requirements due to either fugitive or stack emissions.

Lower stack emissions are expected to decrease the intensity of localized exceedances of the hourly limit set out in the control order. However, the frequency may or may not decrease depending on stack gas emission parameters. Inco should provide additional information on this, with potential solutions aimed at meeting the requirements of Reg. 308.

The company has asked the Ministry to review its objectives in relation to Reg. 308 (newly proposed Clean Air Program) before expenditures for smelter changes required under Reg. 660/85 commence.

Fugitive emissions are currently causing numerous exceedances of Reg. 308 in Copper Cliff. Modifications in the smelter flowsheet may reduce but not eliminate these exceedances. Inco should provide information on its development work to reduce these emissions beyond 1994.

Inco indicated that "...the number of exceedances of the (air quality) criteria have significantly increased".

The Ministry is interested in Inco's data leading to this conclusion and in the company's projections on future exceedances after the new program is implemented.

General

No detailed scheduling regarding approval applications is included in the fifth progress report but the company has expressed serious concerns over meeting required SO_2 emission limits if the Ministry delays in approving the company's applications for the necessary changes and installing new processes.

A Certificate of Approval will be required for every process change or technology change. Each program will be reviewed and assessed individually as these changes develop over the next implementation phase. Realizing the fact that a new unproven technology will be implemented, a Conditional Certificate of Approval should be issued. The conditions should require Inco to indicate suitable alternatives in the event of failure of parts or all of the new technology, and a schedule for putting the alternatives in place which will ensure that the company will meet the emission limits as set out in Regulation 660/85.

Proper integration of various operations with the new acid plant is required to avoid unnecessary delays.

There is no information provided in the progress report on how the company intends to meet the 1990 reduction target of 525 kt. Detailed information is anticipated in the final report.

New capital and operating costs required to meet reduced emission levels, financial, and socio-economic considerations have not been discussed in the progress report.

Information on capital cost, operating cost, estimated savings (recovery), and projected reduction in emissions should be provided for each element of the company's abatement plan. If an element is being eliminated on economic grounds, the company should explain in detail.

The company, in its final report, should provide a contingency plan in the event that some of the abatement program elements are not successful (e.g. bulk smelting) with respect to meeting the requirements of Reg. 660/85.

FALCONBRIDGE

Falconbridge Ltd. operates a nickel/copper smelter and ancillary facilities in Sudbury and produces sulphuric acid from the sulphur contained in the ore. Falconbridge produced 72 kt of acid SO_2 emissions last year, operating at 69% of its rated production capacity.

Countdown Acid Rain requires Falconbridge to:

- limit its SO_2 annual emissions to 154 kt effective 1986, and
- reduce the SO_2 emissions from its Sudbury smelter complex to no more than 100 kt per year by 1994.

FALCONBRIDGE'S JULY 31, 1988 PROGRESS REPORT

SUMMARY	ONTARIO GOVERNMENT RESPONSE
	The company has met most of the requirements stated in O. Reg. 661/85.
Estimated R&D budget until 1994 has been updated and shows an increase of $2 million over previous estimates. This total includes $2.7 million for "Comprehensive Supplementary Emission Control System" (COSEC).	COSEC is not part of the Regulation 661/85 package but rather a control order requirement.
Company's final report will outline estimated capital costs for various changes.	
Most of the modifications needed to meet SO_2 emission limit will be retrofitted to existing processes and will be carried over several years.	No indication has been provided by the company on the scheduling or required plant shut-downs. This could be a bottleneck if the company has to meet its Ni/Cu production commitments in the future.
The company's approach in achieving lower SO_2 emissions has not changed conceptually, i.e., removing up to 65% of the sulphur present in the concentrate during roasting. However, problems still persist in downstream areas, namely, handling calcite smelting and fluid-bed roaster off-gas and fixing SO_2 in the acid plant.	

- Roaster capacity problem has been overcome by using O_2 enriched air and submerged coolers which could provide the needed 25% capacity at design rate.

- Problems in roaster off-gas cleaning and particulate removal are tackled adequately by cyclone modifications (primary/ secondary) and ESP operation improvement.

  The company should not reject rigid mast electrodes over standard wire electrodes based only on particulate collection efficiency (no change) but should also take into account maintenance.

- Preliminary survey done on current acid plant by Fenco Consulting Engineers indicates extensive changes are needed, including higher capacity SO_2 blower, more catalyst, and a large SO_3 absorption tower.

  Since the company has to go through major changes in the acid plant to fix additional SO_2 generated from the deep roast operation, the company should also look at the possibility of improving SO_2 conversion efficiency from 95 to 99+% by converting to a double contact process.

- Electric furnace smelting of low sulphur calcine has still many problems to overcome. The company is going ahead with the planned program of installing copper fingers and blocks for additional cooling in No. 1 and 2 furnace walls. Operating the furnace with higher freeboard temperature has not met with much success. Further work is planned for '88-'89 in collaboration with Ontario Hydro to test various reductants and different operating methods in a pilot electric furnace to avoid matte cooling and increased metal losses.

- Converting of high grade matte without high metal losses will be tested using a process computer. An advisory model for converter operation has been developed and calibrated.

- Converter slag cleaning, an in-house technology, has reached commercial application. The company will be only looking at fine tuning of this operation. This unit will reduce overall metal losses to slag and allow electric furnaces to operate at design rate with reductants.

- Further actions to reduce fugitive emissions from the facility will also improve local air quality and reduce SO_2 exceedances.

Pyrrhotite (PO) Rejection

This is progressing well as per plan. Research and pilot-plant studies are still to be completed in many areas and current schedule indicates work will be completed in the third quarter of 1990. Present results indicate an 11% improvement in PO rejection on a plant scale basis. Further success has been reported in magnetic separation of additional PO after regrind ore prior to flotation. Work in other areas, e.g., column flotation, use of larger flotation cells (OK), alternative chemical agents and improved process control, continues.

The company has still not outlined their back-up technology for meeting SO_2 emission limits. The company should give an estimate of the potential SO_2 emission reduction from this program for proper evaluation in their final report.

A Certificate of Approval will be required for every process or technology change. Each program will be reviewed and assessed individually as these changes develop over the next implementation phase. Realizing the fact that a new unproven technology will be implemented, a Conditional Certificate of Approval should be issued. The conditions should require Falconbridge to indicate suitable alternatives in the event of failure of parts or all of the new technology, and a schedule for putting the alternatives in place which will ensure that the company will meet the emission limits as set out in Regulation 661/85.

The company has not reached a stage in their research and development to allow a statement of the degree of sulphur reductions that can be achieved in each project. This must be

provided in the 1988 final report. New capital and operating costs required to meet reduced emission levels, financial, and socio-economic considerations have not been discussed in the progress report.

Information on capital cost, operating cost, estimated savings (recovery), and projected reduction in emissions should be provided on each element and summarized in one table in the final report. If an element is being eliminated on economic grounds, the company should explain in detail.

The company will obviously be carrying out development well into 1989, and in some instances 1990. The question arises whether retrofit of acid plant, electric furnaces, gas exhaust systems and milling circuits can be accomplished by the end of 1993, based on the company's concern that the technical resources within the company are severely overburdened.

ALGOMA STEEL (WAWA)

The Algoma Steel Corporation Ltd. operates an iron sintering plant in Wawa (270 km northwest of Sault Ste Marie). Countdown Acid Rain limits the SO_2 emissions from the operation to 180 kilotonnes per year in 1986 through 1993, and to 125 kt in 1994 and thereafter. The previously existing limit was 285 kt.

As of August 1, 1986, Algoma Ore Division decreased its production capacity at Wawa from 2.0 million tons per year to 0.9 million tons per year which resulted in an SO_2 emissions level of 85,000 tonnes for 1987.

ALGOMA STEEL (WAWA) JULY 31, 1988 PROGRESS REPORT

SUMMARY

The fifth progress report indicates that the company's previous position to meet the 1994 emission requirements remains unchanged. In addition, the company will continue to use low sulphur iron oxides to further reduce the level of sulphur dioxide discharged from the sinter plant.

ONTARIO GOVERNMENT RESPONSE

The reporting requirements of Regulation 663/85 have been met with respect to the July '88 progress report.

The company appears to be able to submit the "Final Written Report" required by Section 4 of the Regulation without further delay.

Information on capital cost, operating cost, estimated savings (recovery), and projected reduction in emissions should be provided on each element and summarized in one table in the final report. If an element is being eliminated on economic grounds, the company should explain in detail.

Since Dofasco is in the process of taking over Algoma's operations, some changes are expected. The Ministry has contacted Dofasco reminding them about the requirements of Regulation 663/85.

ONTARIO HYDRO

Ontario Hydro operates coal-burning electrical power generating stations at five locations in Ontario; three major plants in southern Ontario, and two smaller plants in the north-west part of the province. Two oil-fired units Lennox and Addington (half of a generating station) near Kingston were re-activated in December 1987 to provide system peaking capacity. Overall, Ontario Hydro produced 332 kt of SO_2 last year. Based on preliminary estimates, Ontario Hydro acid gas emissions for the first half of 1988 amounted to 168 kt of SO_2 and 30 kt of NO_x, respectively. It is forecasted that the 1988 year end acid gas emissions would be below 1987 levels.

Countdown Acid Rain prescribes a schedule of reductions in the SO_2 legal limits, from 370 kilotonnes in 1987 to 240 kt in 1990 and to 175 kt by 1994. There are also corresponding limits on the sum of SO_2 plus nitric oxide (NO), namely, 430 kt, 280 kt and 215 kt in 1987, 1990, and 1994, respectively. These limits apply regardless of anticipated future increases in demand for electricity.

In May 1987, the government removed an emission banking provision. No change was made to the actual emission limits.

ONTARIO HYDRO'S JULY 31, 1988 PROGRESS REPORT

SUMMARY	ONTARIO GOVERNMENT RESPONSE
	Hydro's fifth progress report has satisfied the formal requirements of O. Reg. 281/87.
Ontario Hydro has formally submitted its program Environmental Assessment (EA) for the retro-fit of flue gas desulphurization equipment on selected coal-fired generating units.	Activity has continued with respect to EA procedures, to ensure that Hydro is in a position to retro-fit scrubbers. The official government review of the EA currently being developed is based on comments from government ministries, public agencies, and commissions. The government review of the EA will soon be published and the 30 day public review period will follow.
The utility is also looking for ways to improve on its ability to remove additional acid gas emissions in the early 1990's by using low sulphur fuels.	In the final report, it is anticipated that Hydro will provide greater context for the direct abatement actions which are underway, by discussing other options more fully. These could include electricity conservation measures, parallel generation including co-generation, purchases or development of indigenous hydro-electric power, increased use of low sulphur coal

	or new clean coal technologies, and potential for natural gas as a replacement fuel for coal.
Testing of sulphur trioxide flue gas conditioning equipment at Lambton and Nanticoke generating stations is planned for 1988 to improve the efficiency of operation of electrostatic precipitations. If successful, the equipment will be considered for installation at these stations with a 1990 in-service date.	This testing program is unrelated to the Countdown program to abate SO_2 and NO. The Ministry has granted approval for the experimental program, however, before the equipment will be used in routine operation, Ontario Hydro should assess the impact of sulphur trioxide on the total acid gas emissions before implementation.
Ontario Hydro is planning to use a number of demand management and clean energy supply alternatives. Its plan calls for load shifting, electricity conservation, efficiency improvements and non-utility generation to reduce the need to supply 5,500 MW of electrical peak demand by the year 2000. Current forecast suggests that the first pair of scrubbers will be required in 1994 and a second pair may be required by 1996.	Up-dated information on actual and projected demand growth should be provided. Inclusion of short and longer-term contingency plans for meeting Ontario Hydro's emission targets, including estimates of the associated costs would be desirable.
	Information on capital cost, operating cost, estimated savings (recovery), and projected reduction in emissions should be provided on each element and summarized in one table in the final report. If an element is being eliminated on economic grounds, the company should explain in detail.

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